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MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION

F. B. LINFIELD, Director

BULLETIN NO. 62

THIRD ANNUAL REPORT

OF THE

STATE ENTOMOLOGIST

BY

R. A. COOLEY

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CONTENTS.

The Codling Moth in Montana........................... 185
- Introduction........................... 185
- Popular Names........................... 186
- Geographical Distribution and Occurrence in Montana.... 186
- Life Zones in Montana........................... 187
- Means by Which the Codling Moth Spreads........... 189
- The Future of the Codling Moth in Montana........... 191
- Ways by Which the Progress of the Moth may be Delayed 191
- Natural History of the Codling Moth................. 193
- The Egg........................... 193
- Egg Laying........................... 194
- Incubation of the Egg........................... 195
- The Young Larva........................... 195
- The Larva Entering the Fruit........................... 196
- The Fullgrown Larva........................... 197
- The Coccoon and Pupa........................... 197
- Mortality Among the Larvae During Hibernation 198
- The Moth........................... 198
- Dates of Appearing of Different Stages............... 199
- The Food of the Codling Moth........................... 200
- Remedial and Preventive Treatment for the Codling Moth.. 202
- Maintaining a Wholesome Sentiment.................. 202
- Enforcing the Horticultural Law........................... 203
- Use of Second-hand Boxes........................... 203
- Spraying........................... 203
- Arsenical Compounds for use in Spraying............... 204
- Spraying Machinery and Appliances.................. 205
- When to Spray........................... 206
- Thoroughness in Spraying........................... 207
- Banding for the Larvae........................... 207
- Apple-tree Planting and Spraying........................... 208
- Clean ulture vs. Clover Crops........................... 209
- Care of the Fruit Store-house........................... 209
- Treatment Required by Old Orchards.................. 210

The Plum Gouger........................... 211
- Occurrence in Montana........................... 212
- Geographical Distribution........................... 213
- Extent of Injury Caused by the Plum Gouger........... 215
- Natural History........................... 216
- Time of Appearance........................... 216
- Egg Laying........................... 216

  The Larva, Pupa and Adult 217
  Remedies 217
The Corn Worm 219
  Geographical Range 219
  Other Food Plants 219
  Injuries to Corn 220
  Description and Habits 220
  Remedies 222
The White Lined Morning Spinx 224
  Geographical Distribution 224
  Food Plants 225
  Description and Life-history 225
  Remedies 227

THE CODLING MOTH IN MONTANA.

INTRODUCTION.

Apple growing in Montana has passed far beyond the experimental stage, and several hundred thousands trees are planted each spring. The total number of trees that have been planted up to this time is upward of two million. Some parts of the state which a very few years ago were practically unheard of as producers of apples are pushing ahead and promise to be close rivals of Ravalli, Missoula, and Flathead Counties. Many large orchards of young trees are coming into bearing and as one year after another passes the industry more and more invites a full confidence. As was expected and has been predicted, the codling moth has appeared and established itself in more or less isolated localities in practically all the fruit growing regions of Montana. It cannot be said that it has yet become very injurious but judging from the experience of other localities, as well as that of our own people up to this time, it seems certain that this moth will gradually assume a most important place in our fruit industry. As the bearing trees grow larger and as more orchards come into bearing, it will progressively make its its presence felt and at no very distant date it will be necessary for many growers to prepare for systematic and thorough spraying of their trees. The codling moth is here to stay and has demonstrated again and again within the borders of our state that the amount of fruit it can take, when left unchecked, will almost if not quite, absorb the profits of the industry. We are glad to be able to say that our fruit growers are, for the most part, well aware of the situation and are anxious to take and keep every possible advantage over this pest.

In response to a growing necessity for accessible information regarding the codling moth this paper has been prepared. A general account published from this Station in 1900 has long been out of print and a short bulletin distributed in 1903 giving such brief information as to enable us to spray effectively is nearly exhausted. Through the present paper we desire to put in as brief space as possible such facts and discussions as will enable our citizens to become acquainted with the whole problem of the codling moth as a factor in the commercial production of apples in Montana. A few excellent publications regarding the codling moth have appeared in the United States during the past few years and we have drawn freely from their pages, discussing the facts, however, in the light of Montana's conditions. Observations by the writer been incorporated also.

POPULAR NAMES.

It is proposed here to draw attention to the fact that the name and spelling employed at the head of this article is the one now in general use and believed to be the correct one. Some persons in Montana employ the name "Codlin" moth. Prof. Slingerland of Cornell University several years ago made an extended search into the literature of this question and arrived at the conclusion that the name "Codling" deserved preference. Some persons having in mind the larval stage of this insect use the name "apple worm" or "fruit worm", but while the use of this name is excusable, it is less desirable for the reason that it overlooks the fact that the moth and the larvae are of the same species.

GEOGRAPHICAL DISTRIBUTION AND OCCURRENCE IN MONTANA.

The original home of the apple is southeastern Europe and it is supposed that in prehistoric times the codling moth fed upon wild apples in a natural state. With advancing civilization the apple has been introduced wherever man has gone and the codling moth has closely followed and besides now occuring throughout the United States and in Canada wherever the apple is grown it is known to be present in Europe, Africa, New Zealand, Australia and Brazil. Mr. C. L. Marlatt during his etensive travels in Japan and China a few years ago did not observe this insect there but more recently Prof. A. B. Cordley of Oregon has learned, probably through correspondence, that it has reached China.

In Montana the codling moth has been authentically reported from Thompson Falls, Missoula, Hamilton, Woodside, Kalispell, Big Fork, Helena, Forsyth, Park City, Billings and Joliet. The orchard industry is still young in Montana and the codling moth has not yet done a great deal of damage, though it has plainly shown its ability to exist in Montana's climate and to be very injurious. In Missoula where the State Board of Horticulture has been faithful in endeavoring to stamp it out or reduce it to the smallest numbers, it was still to be found in considerable numbers last summer

(1905). The difficulties attendant upon the extermination or even the material reduction of this insect in back yards and other small orchards within the city limits can scarcely be appreciated by those who have not made a study of the life habits of this insect and of the conditions in such orchards. A similar situation is to be found in Flathead County. The writer has not had opportunity to make an examination of the orchards where the moth has been working in this county but has been informed that the pest has been greatly reduced in numbers. The accompaning photograph (see plate III) is of a backyard in Missoula. The photograph was taken to show the method of banding, and the background and surroundings were not particularly noticed in taking the photograph. The picture shows admiralby the adverse conditions under which the State's officials are working in fighting this pest. The cracks and corners in the board fence and old door as well as the hiding places to be found in the vegetation and in the unstirred soil make a combination of conditions all but impossible of overcoming unless a complete renovation is made. Contrast with this the photograph shown in plate IV. Nothing is to be seen in this orchard but the trees, the soil and the shadows of the trees. In such an orchard as this a much greater measure of success may be obtained.

LIFE ZONES IN MONTANA.

The Division of Biological Survey of the Department of Agriculture has made a study of the temperature and other features that control the distribution of plants and animals. Of the various factors aside from such obvious barriers as mountains and oceans it has long been known that temperature is the most potent factor that governs the limits beyond which particular species cannot go. In his interesting and valuable paper on this subject, Prof. C. Hart Merriam states that "the northward distribution of plants and terrestial animals is governed by the sum of the positive temperatures for the entire season of growth and reproduction, and that the southward distribution is governed by the mean temperature of a brief period during the hottest part of the season." These statements may be considered as laws.

A minimum temperature of 60 degrees C (43F.) was assumed as being the lowest at which plants were physiologically active and

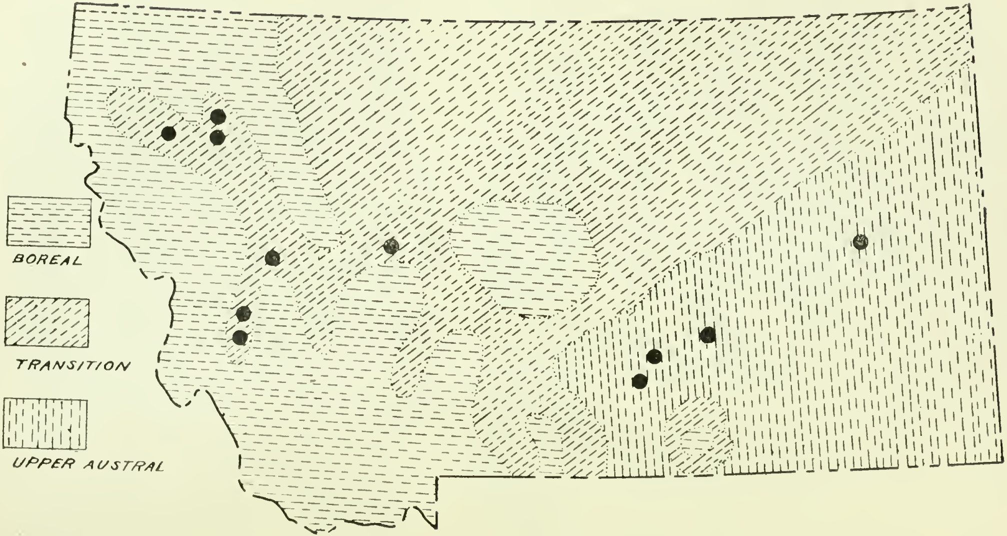


Figure 1. **Outline map of Montana showing the life zones.** The black circles mark the positions of colonies of the codling moth.

animals reproductively active. The degrees of normal mean daily heat in excess of the minimum stated were added together for each station beginning when the normal mean daily temperature went higher than 60 degrees C in the spring and ceasing when it fell to the same point in the fall. Connecting by isotherms the points in the United States thus obtained it was found that the isotherms conformed very closely with the northern boundary of the several life zones. In determining the southern limits for experimental purposes the mean normal temperature of the six hottest consecutive weeks was arbitrarily chosen and platted. When drawn, the isothermal lines conformed so closely with the southern boundaries of the boreal, transition, and the upper austral zones that the matter was not carried further.

Three of the life zones thus determined occur in Montana, viz: the boreal, transition and upper austral. The accompaning outline map of Montana, figure 1, shows the territory covered by these life zones in this state. This map was drawn from Prof. Merriam's bulletin above referred to (Bulletin 10, Division of Biological Survey, U. S. Department of Agriculture, 1898). The black circles indicate the location of the colonies of the codling moth and are based on notes in the Entomologist's office. It may be seen that all the colonies are in the transition and upper austral zones. The upper austral zone has the mildest climate of the state and is much more favorable to the development of the codling moth as well as to the growth of apples. It may be expected, therefore, that when Montana's orchards have come more fully into bearing and the codling moth has become more widely disseminated this part of the state in the southeastern corner will have a higher percentage of damage than the western portion.

The boreal zone does not permit of the growth of apples on account of its higher altitude and colder climate.

MEANS BY WHICH THE CODLING MOTH SPREADS.

Over long distances the most common means by which the moth spreads is undoubtedly in fruit packages sent to supply commercial demands. It is not strange that by this means the moth has extended itself to almost every fruit growing region in the world for, when we analyze horticultural and commercial practices we find a chain of conditions almost perfectly adapted to that end:

Along with the development of a new agricultural country apple growing naturally is taken up. Young trees are brought in, planted and cared for, until they produce fruit. In the meantime, in response to public needs, merchants purchase and ship in the surplus apple crops of older settled regions. Along with the imported apples are brought the larvae or pupae of the codling moth. These in their cocoons may be secreted in the corners of the boxes or barrels containing the apples or they may be secreted in any other articles whatsoever that were shipped in the same car or that later were stored in the warehouse near them. They may be even hidden in the cracks and crevices of the freight cars themselves. In these freight cars, after the fruit has been removed, they may go hundreds of miles bearing another kind of merchandise and be side tracked in another town. Such unsuspected cars may readily establish colonies of the moth, for sooner or later the adult or moth stage is reached and the moths, following a natural instinct, go in search of apple trees. This may occur in the same season or after a winter spent in the freight car, the fruit cellar, or wherever the cocoon was made or has been lodged by the merchant. Empty apple boxes may be thrown out on a rubbish heap or even filled with groceries and taken by the farmer to his home, often surrounded by apple trees.

Knowing the habits of this insect and enumerating the various ways by which it may be carried over greater or less distances we are led to wonder that Montana has been so slow to become generally affected by it.

Small orchards in the centers of population in new countries are naturally the first to become infested and these orchards become local centers of distribution for the surrounding country. Over short distances the moth is mainly dependent upon its power of flight for spreading and though a single moth may fly but a very few miles, in the course of a few years, in a country where orchards are not far apart, by going from orchard to orchard great distances may be covered. Thus, through the combined means here outlined the tendency is for the codling moth to enter and establish itself wherever the apple is grown in any country on the globe. One moth of either sex is incapable of starting a colony but a pair or more may often be found in a single empty fruit box.

THE FUTURE OF THE CODLING MOTH IN MONTANA.

The writer believes that the future of this insect in Montana will be of one gradual extention of the area infested and increase of damage done. As orchards become older the insects will find more favorable condition for their existence and while now only a small part of the opportunities afforded, result in the production of colonies of the moth, in the future new colonies will appear with greater frequency.

Figures are not available by which we can state the exact number of trees now standing in Montana but two millions is certainly a conservative estimate. When in full bearing these trees will produce, in an average crop, year after year, say three boxes per tree. At one dollar per box the annual apple crop will then be worth $6,000,000. It seems probable that the time is not far distant when the codling moth if left to itself will take one fourth of Montana's apple crop. Thus if the situation has not been overstated, should Montana neglect or fail to control the codling moth she would pay a penalty of $1,500,000 annually. Considering available figures from other states this sum is certainly a conservative estimate of the damage the codling moth is capable of doing in Montana. It should be borne in mind also that this sum would come not only out of the gross receipts but particularly from the fruit growers' profits.

There can be little doubt that eventually the codling moth will be in practically every orchard in Montana but that time may be delayed and in the meantime the fruit growers be so educated that Montana will never suffer the heavy losses experienced by some other sections nor lose her reputation for fruit free from codling moth.

WAYS IN WHICH THE PROGRESS OF THE MOTH MAY BE DELAYED.

A great eventual financial saving may be made by retarding the dissemination of this insect. In so retarding the moth both individual and concerted effort will be required. We believe that much has already been done in this direction by the Experiment Station and the Board of Horticulture through the publicity that has been given the subject and the actual preventive and remedial measures employed.

In enforcing the horticultural law, since the funds are furnished by the general public the general public as well as the fruit growers should be protected and receive the benefit, and even though it may appear to work some hardships on individuals such rules should be enforced as to prevent the rapid spreading of this baneful pest. Those individuals who fail to see that they are not serving their own interests in failing to spray their commercial orchards should have them sprayed by the state officials and the expenses should be charged against such properties. Infested orchards in towns, becoming a menace to commercial orchards in the vicinity should be sprayed by, or under the supervision of, state officials and insofar as the work is a benefit to the owners they should pay the expenses but the balance, if there be a balance, should be paid from public funds since it is a public benefit to have such spraying done.

The writer feels confident in stating that in such towns as Helena, Missoula, and Kalispell without the expenditure of enormous sums, which Montana will never feel warranted in appropriating, the codling moth cannot be actually exterminated tho' it may be reduced to very small numbers. When reduced to such small numbers the danger of spreading to commercial orchards will be reduced to a minimum. The state should pursue a vigorous warfare against the pest in each center of population in order that our great fruit industry, whose future benefits to the state should be measured not alone by the number of dollars it will return in the form of fruit but by the good name the state will acquire for being a producer of large quantities of clean apples, with all the pleasing associations of apple growing, may be fostered and protected.

Montana apple growers should begin spraying for the codling moth as soon as the pest first makes its appearance in the orchard. In other apple growing sections growers have been obliged to go to great expense and trouble, after the insects became very injurious, to reduce the numbers to a point where only four or five percent of apples are destroyed, and reaching this point they have been greatly pleased and have continued to spray to keep the injury down. It will be very unwise for a Montana grower knowing that he has the moth generally scattered through his orchard to neglect to spray and thus allow the pest to increase and after a few years be obliged to go through an extensive operation of fighting it down in self defence. Rather, at the outset he should keep the advantage he already has.

NATURAL HISTORY OF THE CODLING MOTH.

Contrary to the opinion of many fruit growers, they themselves should be famaliar with the details of the story of the life of the codling moth. Seasons vary in forwardness and with the season varies the proper time to spray for best results. The fruit grower like the entomologist, to secure the best results, should be so conversant with the facts of the life-history of this pest that have a bearing on the manner of treatment, that he can safely draw his own conclusions from time to time as the season develops. Thus, he will know when to spray and how often to spray. The following summary of the life history is presented with a view of furnishing a summary of the general information. It is hoped that with these basic facts in the mind of the orchard owner he will make a study of the question as it affects his own interests.

THE EGG.

The freshly laid egg of the codling moth as seen with the naked eye appears as a milk white speck somewhat oval in shape one twenty-fifth of an inch across by a very little more in length. Its manner of reflecting the light is characteristic and materially aids in locating it. A profile view shows the egg to be nearly hemispherical in its central portion with the oval shaped edge greatly flattened out. As the embryo develops the color may become changed to a yellow-reddish tinge due to a ring of reddish color marking the position of the curled caterpillar inside. In a previous report we have called attention to a superficial similarity between the eggs of the codling moth and the bud moth. This discussion occurs on page 205 of the 1st Annual Report of the State Entomologist. In the Second Report, on page 146, further observations, made by an assistant, Mr. Burle J. Jones, are recorded. The bud moth eggs are laid apparently with less care as to location than are those of the codling moth, those of the former being placed on both upper and lower surfaces of the leaf, those in the latter position being less abundant..

EGG LAYING.

The eggs are laid both on the leaves and on the fruit. Since the publication, some years ago, of Prof. Cordley's suggestion that the moth does not deposit her eggs on the young fruit, on account of the pubecence, which later in the development is lost, I have been much interested in observing where the eggs are laid in this respect. These observations go entirely to bear out Prof. Cordley's opinion and in the writer's mind it passes as a settled fact that while the moth prefers to lay eggs on the fruit she will lay them on the glossy surface of a leaf that is smooth rather than on the felty surface of a young apple. Later in the season when the apples have lost their pilose coating most of the eggs are laid on the fruit in preference to the leaves or some may be found in the latter position. At Missoula it has been observed that the egg is sometimes laid on a smooth spot on a young apple surrounded by the felty pile. This habit of avoiding the hairy surfaces in depositing eggs appears to be but a reasonable precaution of the parent, for if deposited on the surface of the pile it would not only be in danger of drying from below but also would be liable to be shed to the ground along with the hairs unless it hatches before the hairs are shed. Thus it has come about that various authors have recorded that the eggs of the first generation are laid largely on the leaves while those of the second are more common on the fruit. It has been found, however, that where the fruit is scarce more eggs are laid on the leaves.

Various writers have stated that the eggs are laid at night. As published in a previous bulletin of this station, the writer has seen a moth busily engaged in egg laying just before sunset and under the observations of Mr. Simpson it was found that for the most part the eggs are laid in the late afternoon and early evening. It seems entirely possible that during a season of warm evenings the eggs are laid more naturally after dark, but that if warm evenings or nights do not occur the moth urged by the necessity of depositing her eggs may lay them in the afternoon as dusk approaches rather than not at all.

As bearing on the number of eggs laid by one female Mr. Simpson made two definite observations. In a limb cage in which one moth had been placed he found 21 eggs and in another 25 eggs but the second moth's career was stopped by a spider. With various facts in view Mr. Simpson reached the opinion that the maximum number of eggs laid by one moth is about 50 and the average between 30 and 40.

From the writings of various observers it appears that egg laying begins about 5 or 6 days after the emergence of the moth. It often occurs in Montana that cold rainy spells come at the time that part of the first brood of moths is on the wing and from observations made by the writer and published elsewhere, there can be little doubt that the moth may live over a considerable length of time waiting for an opportunity to lay her series of eggs, her physiological activities in the meantime being retarded by low temperatures. The writer has kept a newly emerged codling moth in a gauze covered bottle in a refrigerator for a period of two months.

INCUBATION OF THE EGG.

Widely varying records of the duration of the egg stage have been published, the time recorded, varying from four to eighteen days. Actual observations have shown that the period of incubation varies and the principal if not the only factor is a variation in temperature. We believe that the average duration of this stage in Montana is very close to 12 days.

Having gone through its development in the egg the larva emerges through the shell at one end leaving an irregular crack at the point of exit.

THE YOUNG LARVA.

All the damage done by the codling moth is attributable to the larva. The newly hatched larva is about one sixteenth of an inch long, whitish in color, with the head, a shield just behind it and a shield at the posterior end of the body, black. Later in life the parts that were at first black become brownish. After a short period of life on the surface of the apple the larva begins to bore into the fruit. However, some larvae, perhaps many, eat from the surface of the leaves before finding their way to an apple. Mr. Simpson appears to be of the opinion that eating from the surface of the leaves is a general habit of the young larvae but the truth concerning this point, while of great importance has not been established by actual observations. The importance of the question lies in the influence it may have on the effectiveness of arsenical sprays.

THE LARVA ENTERING THE FRUIT.

The larva seems to find difficulty in gaining entrance through the smooth exposed skin of the apple. With the small weak jaws it is unable to break through without some advantage of position or aid through a roughened spot. A leaf is sometimes fastened to the side of the apple and from between the two, a small patch of skin is gnawed away. At times the point where two apples touch each other is selected. Wherever the young larva crawls it spins a web which furnishes a footing by which it adheres to the apple and is aided in gnawing the skin. At the calyx end of any apple, however exposed, a favorable point of entrance is furnished in the small protected cavity under the calyx lobes where the skin is thin; and it is not strange that a large percentage of the larvae, particularly of the first generation, enter at this point.

The larvae of the second generation are known to enter for the most part on the sides of the apple spinning a web at the point where they intend to enter. Some irregular or roughened place is preferred.

It has been observed that in biting out small bits of the skin none are eaten. The larva has been seen to actually back out of the partly formed burrows in order to deposit on the surface bits of apple taken from just below. When the larva has finally gnawed into the apple it turns about and spins a silken web over the opening. In view of these facts it is not clear how the fatal dose of poison on sprayed fruit is taken into the system.

As above stated the larvae of the first brood enter principally by way of the calyx cup. In Montana the calyx cup has closed long before the larvae are hatched and it is necessary for them to work their way through between the closed lobes or by boring a small hole through the base of a lobe. Careful investigations by Slingerland, Gillette, and others have shown that as a rule about 80 per cent of the first brood enter the fruit in this way. The other 20 per cent go in at the side or at the base of the stem. By far a greater part of the second generation enter by the side of the apple.

These facts are to be borne in mind in connection with spraying operations.

THE FULL-GROWN LARVA.

The large larva is the best known form of the codling moth but we may here call attention to some characteristic features by which this species may be distinguished from other kinds of larvae. The body is pale yellow in general color excepting the back which is usually pinkish. While in the very young larva the head is black, when older it is brown, as are also the two shields, one just posterior to the head, and one of the opposite extremity of the body. Three pair of rudimentary legs occur at the anterior end and on the posterior parts are five pair of pro-legs which are of service only through the larval stage. When full grown the larva is about three fourths of an inch in length.

THE COCOON AND PUPA.

When the larva has reached full size which requires about 20 days it bores to the surface making the familiar large exit opening on the side of the fruit. At the end of the passage a block of frass is formed which is pushed aside as the larva leaves. Absence of the block indicates that the larva has gone.

On leaving the fruit the larva seeks a place in which to form its cocoon. Usually the trunk of a tree is preferred or if the apple has dropped to the ground a suitable place for pupation may be found in a crack in the earth, under a clod of soil, in or under any foreign object, or the larva may ascend the trunk of a tree. On the tree the caterpillar prefers a crack or crevise on such seclusion as can be found in an old knot hole or decayed place running into the heart of a tree or limb. Cocoons may often be found under bits of bark. On smooth well kept trees the larvae often find no suitable place for pupation on the limbs, and in searching for a place find their way to the trunk. Hence the utility of bands as a means of luring scattering caterpillars to their destruction in cases where a very vigorous warfare is waged. Plate III shows a photograph of a trunk of a tree taken to show a bad cavity near the crotch which affords abundant opportunity for many larvae to hide out of reach of their bird enemies. Bands are also shown as properly applied to furnish hiding quarters for the larvae before they reach the cavity in ascending or descending the trunk.

In the case of fruit that has been harvested the larvae in leaving the fruit in the unnatural surroundings of the fruit cellar or merchant's warehouse readily spin their cocoons in the cracks and crevices of the containing boxes or any other similar places which may be found.

With the mandibles the larva gnaws out a shallow cavity in the surrounding substance to receive the cocoon. The wall of the coccoon is composed of silk which is produced by the glands in the head placed there by nature for the purpose. With this silk are mixed numerous bits of wood, bark or other substances gnawed loose by the caterpiller and in this manner the cocoon is made to closely resemble its surroundings. Having constructed the coccoon about itself the transformations are begun. The body contracts, changes color slightly, and is straightened out lengthwise in the cocoon. The larval skin is molted and the pupa with a very delicate covering is left. This covering soon hardens and takes on a brownish color. This change occurs in about 3 days after the cocoon is constructed in the case of the first generation, but in the second brood of larvae, which reaches full growth in the fall, the change from a larva to a pupa does not occur until the following spring, the larva remaining as such though dormant, through the winter months. It has been shown that in some cases the larva may change its quarters in the spring of year, though for what purpose is not clear.

MORTALITY AMONG LARVAE DURING HIBERNATION.

Besides large numbers of larvae that meet death during the winter by being eaten by birds, many die from other causes and may be found during the winter or spring in a blackened condition in cocoons. The cause of the death of these hibernating larvae is unknown. From these causes it is probable that not over one quarter of those larvae that form cocoons in the fall successfully pass the winter and reach the moth stage.

THE MOTH.

Figure 2, Plate II, shows a cocoon and pupa shell vacated by a moth in emerging, attached to the under side of a piece of bark.

PLATE I.

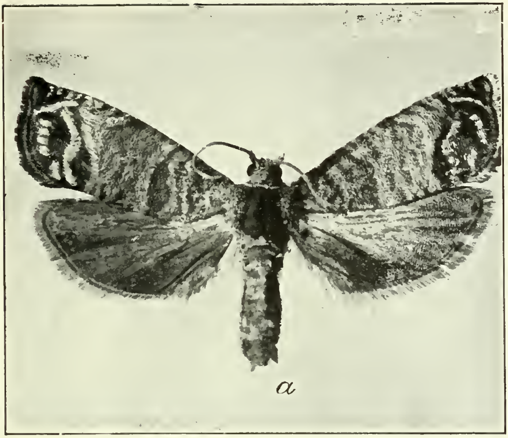


Fig. 1

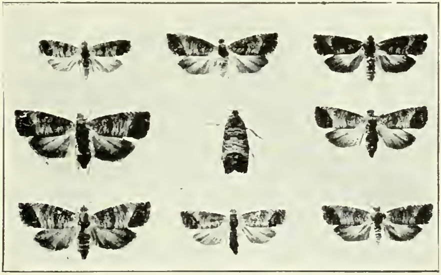


Fig. 2

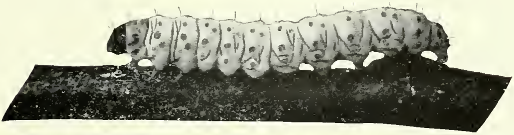


Fig. 3

PLATE II.

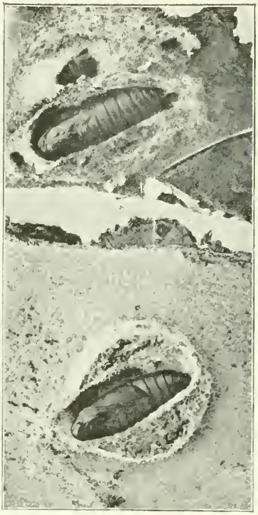


Fig 1

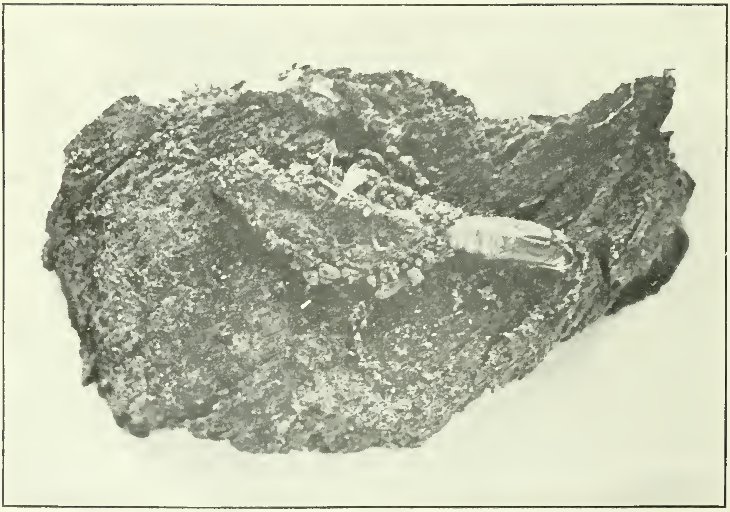


Fig. 2

PLATE III.

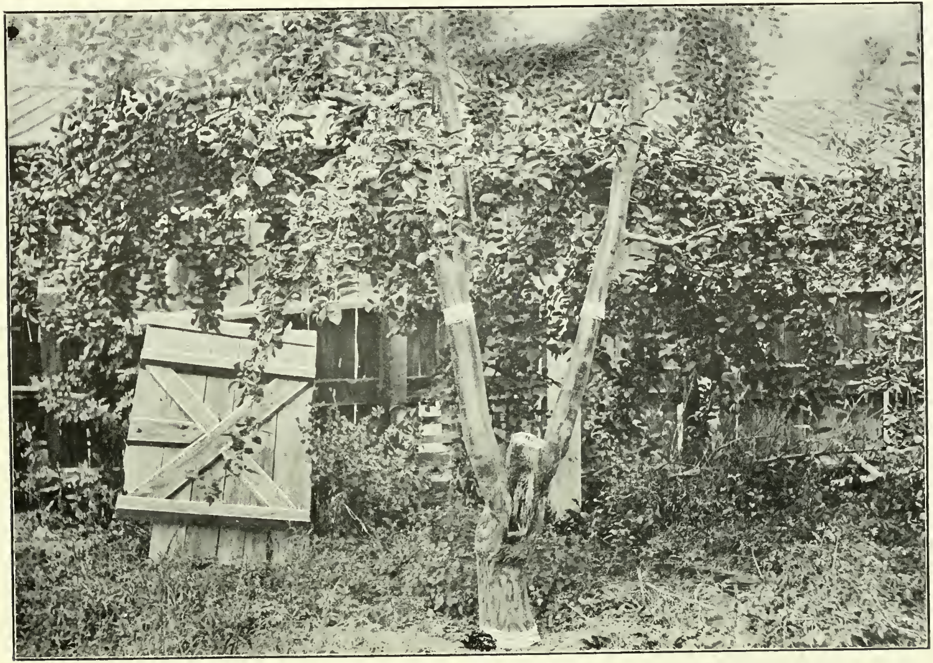


PLATE IV.

Having completed the necessary transformation in the pupal stage, the pupa squirms part way out of the cocoon and splits on the back at the anterior end. Through this split the moth emerges and, after expanding and drying the wings, is ready for flight.

The moth is a beautiful little insect, marked with many gray and brown cross lines. Dark brown spots and streaks of orange and gold occur at the posterior or outer end of the wing. Many moths of this species as caught in the orchard do not have the marking here mentioned on account of losing their scales by rubbing. The adult codling moth is not often seen in an orchard even when abundant. It is shy and during the day spends most of the time lying quietly on the leaves or on the bark. In flying the motions are quick and it is not easy to follow them with the eye. When disturbed and made to fly they soon come to rest again. The moths are not attracted to light to any considerable extent.

The moth probably lives but a few days, if the weather is warm, and if conditions are favorable for rapid deposition of eggs. That cold weather may greatly prolong the life of the moth is indicated by an experiment conducted several years ago (1902). An unimpregnated female moth was kept in a gauze covered bottle in a refrigerator for a period of about two months. When taken from the refrigerator and placed in a sunny window in the same bottle it revived and flew about the bottle but died soon after.

DATES OF APPEARING OF DIFFERENT STAGES.

It is believed that there are two full broods of the codling moth in Montana, and only two. This opinion is based largely upon the habits of the insects at Missoula in the summer of 1902 and partly also on the data accumulated and published by various writers, notably Prof. C. P. Gillette. From the observations of all workers in this subject it seems to be fairly clearly shown that there are only two broods of moths anywhere in the United States. There may be, however, conditions which will produce a partial third brood.

The earliest arrivals of the moths from the over wintered larvae make their appearance in Montana during about the first week in May and others continue to appear until about the 20th of June. The moths are out in the greatest abundance about the first of June. It is probable that the deposition of eggs may be greatly retarded by unfavorable weather so that while under favorable conditions the moth may begin laying within a few days after emerging, if a cold rainy spell occurs at the critical time the operation may be delayed for weeks. This as well as the length of the period through which the moths emerge would account for the overlapping and consequent confusion of broods.

The first eggs are laid, in the region of Missoula, at about the first week in June, the first larvae appearing about 12 days later. The first eggs of the second brood are produced about August 10 and the first larvae of this generation appear some 12 days later. From the fact as previously published, that moths may be seen laying eggs in the orchard as late as October 4 and that the broods overlap in the middle part of the summer it is clearly evident that eggs are being laid and that larvae are hatching practically all summer from early in June on. We have only meagre data upon which to base an opinion regarding when the bulk of each generation of larvae is hatched but we may venture to state that for practical purposes in spraying the middle of June and the middle of August are probably the critical times when the fruit should be well covered with an arsenical poison.

THE FOOD OF THE CODLING MOTH.

The developing or ripe fruit of apples and pears seems to be the natural food of the codling moth though it is thought by some that originally the larvae fed on the leaves of the apple, later acquiring the habit of burrowing in the fruit. While crabapples seem to be less preferred they are sometimes very severely attacked. It should excite no surprise if peaches, plums, prunes, cherries, apricots and quinces are found to be slightly infested also, as there are numerous authentic records of these fruits being attacked. It should be borne in mind that the moth accepts such less preferable food probably only when apples and pears are not to be found in sufficient abundance.

Dr. Riley in 1869 reported that the moth had been bred from the screw bean but the correctness of this record has more recently been brought in question. Some have thought it probable that the fruit of the rose may in some cases serve as food for the larvae. Having this in mind Mr. Simpson, in 1901, carefully examined many hundreds of these rose fruits in the vicinity of a badly infested orchard but did not find a single case of injury to the rose fruit by this species. Yet, when forced by the absence of suitable food it may still be possible that it would attack the rose. To the writer it appears as very improbable that in Montana even a single generation could come to maturity in this way. The seeds of the rose hip later in the season become very hard and unfit as food for an insect with jaws no stronger than those of the codling moth larvae and if the first generation had matured, the second would in all probability perish. This question has engaged the interest of those occupied in fruit growing in Montana because of its connection with the problem of the control of the spread of the species in our fruit growing regions.

The debated question of the nut feeding habit of the moths in other localities is of little practical interest in Montana.

In this connection we would mention the very interesting experiments on the leaf feeding propensity of the larvae conducted by Prof. Cordley and recorded in Mr. Simpson's extended account of the codling moths (Bulletin 41, Division of Entomology, U. S. Dept. of Agr., 1903). Prof. Card in 1897 recorded that young larvae, particularly when confined nibble the leaves of the apple and in his bulletin Mr. Simpson records having seen leaves eaten in cases where he thought the work to be of the codling moth. Prof. Cordley made actual observations which can best be described in his own words.

"It was found on June 4 that these eggs had hatched and nearly all of the larvae were dead. Two of them, however, had fed upon the leaves, were yet alive and had made some growth, notwithstanding the fact that the leaves had been taken from the tree nearly a month before and were therefore presumably not in the most palatable condition. Both larvae were feeding upon the lower parenchyma of the leaf, and one had completely covered itself with a web holding pellets of frass. A recently hatched larva, mounted in balsam, measured 1.35 mm. in length; the larger of these two larvae at this time measured 1.80 mm. in length and was proportionately stouter. Both were transferred to fresh leaves, upon which they fed until June 8, when one of them disappeared. The other continued to feed until June 2, when it too disappeared. However, I noticed a slight discoloration of the lidrib of the leaf, near where the larva had been feeding, and on carefully opening it found the larva feeding as a miner, it having already excavated a tunnel about 15mm. long. I then examined the other leaf, in which I found the larva that had disappeared three days before likewise feeding in the interior of the midrib. The larvae were again transferred to fresh leaves, and by the following morning each had again disappeared within a midrib. Both larvae continued to feed within the midrib until June 16, when one of them, on being transferred to a fresh leaf, refused to eat and soon died. The other, with occasional changes to new pastures, continued to thrive until June 25th, when it was plump and active and apparently in the best of health and spirits. Unfortunately I was then absent from the laboratories for some days, and when I returned the larva was dead. I believe that with careful attention it could have been brought to maturity on a diet of leaves alone. When one considers that it lived and grew for more than three weeks upon leaves that had been severed from the trees sometimes for several days, and that it was apparently more thrifty between June 16 and 25 than in the earlier days of its existence, one must acknowledge that, while the proof is by no means positive, the indications are that codling moth larvae may fully develope on a diet of perfectly fresh apple leaves without ever having tasted fruit."

From the foregoing it seems very probable that in a state of nature which is usually more favorable for insect life than under artificial conditions, however well adjusted, the larvae could come to maturity on a diet of leaves alone.

REMEDIAL AND PREVENTIVE TREATMENT FOR THE CODLING MOTH.

MAINTAINING A WHOLESOME PUBLIC SENTIMENT.

Lack of appreciation of the importance of the production of apples reasonably free from the Codling moth is responsible in a large measure for the enormous losses suffered from this insect in some parts of the United States. The producers of fruit are not alone the ones affected by lack of sentiment in this respect for the general public inevitably receives a poorer quality of fruit for its money if pests are not controlled. It is to the interest of both the producer and the consumer that such a public spirited sentiment be maintained as will lead to the elimination of worthless roadside fruit trees that may be a constant source of devastation and which will bring pressure to bear on thoughtless citizens who do not spray. Such a public sentiment also tends to make easier the enforcement of horticultural laws intended to reduce the injuries done by insects.

ENFORCEMENT OF THE HORTICULTURAL LAW.

Every citizen, whether a fruit producer or not should use his influence to have just and suitable inspection laws enfoced in Montana. A successful horticultural industry in Montana will have a beneficial influence upon every branch of industry. The prospective settler or investor cannot but be favorably influenced by a reputation in Montana for producing large quantities of clean apples. A reliable law conscienciously enforced will do much to prevent the introduction and spread of the pests and diseases of fruit of which the codling moth is probably the most injurious in Montana.

USE OF SECOND-HAND BOXES.

The owner of a young orchard not having been in the habit of securing apple boxes is very liable to harvest his first small crop wholly or in part in second hand boxes bought from merchants in nearby towns. We have already indicated that these boxes are very likely to contain cocoons of the codling moth. Thus taking these boxes into the orchard particularly at the time of the year when summer varieties are harvested, the Codling moth may be liberated in the place where it is most to be feared. In harvesting fall or winter varieties in such boxes the danger is very much less as moths set free in the orchard after all or part of the apples are picked have very much smaller chances to deposit eggs that will mature moths.

SPRAYING.

It has not been shown precisely where the codling moth gets the fatal dose of arsenic on sprayed trees that makes spraying a profitable practice. The habit of the young larva of rejecting from the mouth the skin taken from the surface of the apple is interesting in the extreme. It is supposed that in making its way through the surface of the apple the larva gets enough of the poison to kill it but in this connection the habit of the larva of eating from the surface of the leaves, in some instances, is of great interest.

The fundamental aim of spraying for this pest is to have the fruit and leaves evenly and thoroughly covered with a compound of arsenic at the time the young larvae are entering and it has been clearly shown through practical experience that this treatment is very effective in reducing the amount of injury.

ARSENICAL COMPOUNDS FOR THE CODLING MOTH.

The essential and active agent of arsenical compounds is the arsenic they contain, yet common white arsenic is not suitable for spraying since it is readily soluble in water and hence injurious to the foliage. So far as the foliage is concerned in order that an arsenical compound may not be injurious it should be practically inert. It is therefore necessary to use a compound of arsenic which has a degree of solubility in water so slight that the leaves do not suffer injury and yet which when taken into the body of the insect will be fatal.

Paris green has been the most popular insecticide for the codling moth, and most excellent results have been secured with its use. It is not entirely free of soluble arsenic and to take up that which is soluble, freshly slaked lime is used. A safe formula for apple trees is as follows:

Paris green, 1 pound
Lime, 1 to 2 pounds
Water, 150 gallons

Arsenate of lead is coming into favor as an insecticide for use against this pest, and has some very strong points of advantage over Paris green. The great weakness of Paris green is that being of a granular form, it is easily washed off by showers. The occurrence of rains in the spring season is sometimes a great interference with effective spraying. Arsenate of lead when sprayed adheres to the leaves and apples as a thin film which is not easily mashed off. In Missoula where rains often occur when the first application of the poison is being made this compound has become highly approved by the officials of the State Board of Horticulture. Moreover, it is to be recommended for our local conditions on account of the fact that since the two broods of the moth appear over such a greatly protracted period, the larvae are hatching and entering the fruit through practically all summer. A much larger per cent, therefore, can be killed by an insecticide which when once applied remains on the trees through a long season. Containing as it does a very small amount of soluble arsenic this compound may be applied even to delicate foliage like that of the plum in much greater strengths than Paris green. A third point in its favor is that being white in color the operator can plainly see just what trees or parts of trees have been sprayed. This is particularly desirable in some classes of work where one gang of workmen with a power outfit goes over a large number of trees leaving another party to cover the parts of the trees omitted, thus making a very thorough job at a minimum expense.

Other arsenical compounds are in use but they are not to be recommended for the general fruit grower in competition with Paris green and arsenate of lead.

SPRAYING MACHINERY AND APPLIANCES.

From the orchardists' standpoint there are two classes of pumps, namely, first, those which are worked by hand and second those in which some form of power is used. It is very desirable that a good strong pressure be maintained in the fluid and with power outfits more ground can be covered and with greater thoroughness. A good man power outfit is sufficient for an orchard of about 2,000 trees or less. For orchards above this number a power outfit should be selected from among the various types that can be secured.

Anew style of sprayer is attracting attention in the East and has the approval of some parties who are spraying on an extensive scale. In this outfit no pump is used but the pressure on the fluid is maintained by the use of liquefied carbonic acid gas. The air tight metallic tank containing the spraying mixture is connected to a smaller tank or tube containing the lipuefied gas. When the valve between the two tanks is opened sufficient pressure is produced above the spraying fluid to force it out through pipes taken from the bottom of the tank. It is said that a sufficient and an even pressure can be maintained. In the use of this outfit much depends upon the price of the liquefied gas in Montana. The best figure that has been obtained at present is 29c a pound in Minneapolis This gas can be obtained in the Atlantic states for about 4c a pound and it is probable that better figures can be obtained for Montana. A recent letter from H. L. Frost & Company, Foresters and Entomologists, of Boston, Mass., states that a force of men in their employ, using this gas, in spraying lime and sulphur wash put out 700 gallons with $1.60 worth of gas.

Two lines of hose are all that can usually be used to good advantage even on power outfits. In spraying orchards it is often desirable to have an elevated platform attached to the wagon in order that the operators of the poles may be elevated to where they can spray thoroughly in th tops of the trees as well as among the lower branches.

A device is made by the Spraymotor Company of London, Ontario, and Buffalo, New York, by which the fluid coming from the tank before entering the two lines of hose is cleaned of any objects that would clog the nozzles. By its use much time may be saved particularly where it is necessary to use water from an irrigating ditch which has many small floating bodies in it.

WHEN TO SPRAY.

A review of the facts of the life history of the codling moth indicates clearly that in timing the different sprays that are applied we should in the first place spray so as to lodge the poison in the calyx cup before it closes. Though the larvae of the first generation may not hatch until some time after the cups have closed, they nevertheless to a large extent, go in at the blossom end of the fruit. It is highly desirable, therefore, that the poison be in these cups when the larvae arrive. It is fortunate that the poison lodged in the caylx while open is retained there and more or less protected by the closing of the calyx lobes against being washed out by rain.

Since a part of the larvae of the first generation and a much larger proportion of the second enter the fruit from the side, it is essential that the general surface of the fruit be also covered with poison, and since the larvae may be found going into the fruit in most abundance at about June 15 for the first generation and about August 12 to 15th for the second, these dates should be considered as critical times. It would be well therefore to have the dates of spraying so timed as to have the fruit practically well protected at these critical dates.

THOROUGHNESS IN SPRAYING.

Satisfactory results in spraying for the codling moth cannot be expected if the work is not done with thoroughness. We believe there are many who have sprayed for years who have not yet learned the importance of thoroughness. It is highly desirable that the entire surface of both fruit and leaves be evenly covered. I am informed by Mr. H. L. Frost of Boston who does spraying on a very extensive scale that it is his practice to allow his force of men to go over a large number of trees with a power outfit in a somewhat hasty way covering the bulk of the surface and that later he sends a smaller number of men with another outfit over the same trees to spray all that was omitted the first time. This he does to save expence and secure thoroughness. The first force of men with a large machine would waste much time in attempting to cover all parts of the trees and the second force of men under instructions to complete the job can be made to do thorough work.

BANDING FOR THE LARVAE.

Bands are used to catch scattering caterpillars that have escaped destruction by the poisonous spray. The advisability of their employment depends upon the degree of thoroughness required. Their successful use depends upon having trees that are free, or reasonably so, of other hiding places into which the larvae might go to pupate. Finding no other places the caterpillars crawl under the band thus bringing them all together where they may be readily found and destroyed. We have used and we recommend burlap for banding trees. This may be bought in the bolt and cut up into pieces 8 to 10 inches wide which when unrolled give long strips of the right width for banding. In Missoula we had the burlap cut into pieces of this length in a large paper cutter in a newspeper office. The workmen each take one of these rolls and as they come to the tree to be banded cut off a piece of sufficient length to go round the trunk or limb and slightly lap. It is placed tightly against the tree and a string tied to the middle. Then the top edge is pulled down over the string. In examining the band the outer thickness of burlap is first turned up very carefully and all larvae located and crushed, then the other layer is turned up and examined in the same way. The two edges of the burlap are left turned up until next examined for larvae when they are turned down one at a time and examined.

The bands should be examined once in every 7 to 10 days in order that none of the larvae that go there may be able to come to maturity and fly away. These bands may be a positive injury father than a benefit if neglected and allowed to harbor insectis until they mature.

APPLE TREE PLANTING AND SPRAYING.

Several hundred thousand apple trees are being planted in Montana each year and from observations made by the writer in various parts of the state it is apparent that in many cases little or no attention has been paid to so planting the trees that they may be properly sprayed when they reach full size. It has been clearly shown in various parts of the United States that practically the whole difference between success and failure in apple growing is covered by the saving made through wise and thorough spraying. Montana will be no exception to this generaly rule and when our orchard industry, now in its infancy, has reached the development that it seems sure to attain, various insect and fungous pests will have become widely spread and will require systematic treatment. The time is not far distant when in order to secure the best results from the management of the commercial orchard it will be necessary to spray several times each year.

With these facts before us it is of the greatest importance that in planting new orchards such a distance between trees be established as will permit of passing around the tree with the spray pole. It should at least be possible to drive a two horse wagon through between the rows of trees and to operate a spray pole between two trees in the same row without the interference caused by tangling of limbs of different trees. It is a short sighted policy that prompts a grower to set his trees close together that he may secure a greater crop from the same acreage. This may be carried to such an extent that the crop will be distinctly lessened rather than increased, wholly independent of the benefits to be derived from spraying.

It is fortunate that the proper distance to set trees to get maximum returns in the crop is not less than the distance demanded in order to conveniently and effectively spray. Thus, from both standpoints it is clearly best not to set the trees so close that their limbs can interlock.

Prof. Fisher of the Horticultural Department of this college recommends that in planting new orchards the trees be set not closer than 25 to 30 feet.

CLEAN CULTURE vs. COVER CROPS.

In deciding whether to practice clean culture or to grow cover crops the fruit grower may well bear in mind that much better results may be secured in fighting the codling moth in orchards in which the ground is kept free of vegetation and can be stirred at least during the time that larvae are seeking places for pupation. It will be readily appreciated that the codling moth will find conditions much less favorable in an orchard kept clean as in Plate IV than in one in which legumes, grasses, or weeds are allowed to grow.

CARE OF THE FRUIT STORE-HOUSE.

In harvesting fruit from an infested orchard many larvae will be carried away with the fruit, for partly grown larvae may be in apples that show no exterior sign. It follows then that many such larvae will mature after being taken into the fruit houses and that they will construct cocoons and mature the following spring, then passing through windows and doors, will fly back to the trees. During the spring of the year when these moths are emerging they should be prevented from leaving the fruit house either by keeping the doors and windows closed or by attaching screens. These facts should be borne in mind in constructing such store houses and where possible each season the interior of the fruit house should be thoroughly renovated during the winter or spring after the fruit has been removed. Any moths that emerge from cocoons that escape destruction during the renovation may be killed by hand or by fumigation with potassium cyanide and sulphuric acid.

At this point we should call attention to certain experiments conducted in Ohio by Mr. A. F. Burgess. It is a well known fact that the codling moth hibernates as a larva enclosed in a cocoon. Mr. Burgess finding many larvae in their winter quarters in a fruit house in Deleware, Ohio, took advantage of the opportunity to experiment with the use of hydrocyanic-acid gas as a means of killing the insect in this stage. The formula used was one ounce potassium cyanide of 98 percent purity, one fluid ounce of sulphuric acid and three fluid ounces of water to each 100 cubic feet of enclosed space. After tightly closing the house the gas was liberated at 3:00 p. m. and the door was opened at the expiration of 20 minutes. Without going into details the general results of the experiment was that about 40 percent of the larvae were found to be dead about two weeks after the fumigation. Considering the fact that the house was well constructed and the experiment carefully made it seems to be well shown that this treatment cannot be depended upon for killing the hibernating larvae of the codling moth. The use of this gas in fruit houses after the weather has become warm in the spring of the year so that the moths are flying about the house, may reasonably be depended upon to kill this insect in the moth stage. It is essential however, that the house be of tight construction in order to prevent the escape of the gas.

TREATMENT REQUIRED BY OLD ORCHARDS.

Old neglected orchards are a menace to the fruit industry for they harbor insect pests in abundance. Almost every apple pro- may contain a worm. Beside being left unsprayed the trees of such an orchard may have many scales of bark which offer excellent hibernating quarters. Such trees should either be cut down and burned or brought into condition to produce clean fruit. To recover such trees they should be pruned, the holes should be filled with cement or plaster, and the rough bark removed and burned. Then the trees should be sprayed as in young bearing orchards. As strange as it may seem we are already getting orchards and trees of this description in Montana. Owners not realizing their early hopes from their trees have turned their attention to other things and have neglected the earlier enterprise. The existence of such trees should not be tolerated by the owner of the premises or by public sentiment.

THE PLUM GOUGER.

Coccotorus prunicida. (Walsh.)

The plum gouger and plum curculio placed side by side bear but little resemblance to each other, except that both have a snout or rostrum and are of about equal size, yet the gouger has been ofteh mistaken for the "little turk" in the region where the two species overlap. The adult gouger is very close to one-fourth of an inch in length, exclusive of the rostrum, and is a very prettily marked beetle. The thorax, the head including the rostrum, the underside of the body and the legs, are of an ochre-yellow color, due to the presence of hairs of this color. The wing covers are darker, being of a leaden-gray color, though, when viewed under a lens, the hairs are seen to be distinctly lighter than on other parts of the body. The wing covers are irregularly spotted with yellowish and brownish patches of scaly hairs. A rather indistinct yellowish line occurs on the middle of the back extending from the thorax to the end of the wings. The small, roundish head, deeply sunken into the thorax, narrows down into the gently curved rostrum, which is slightly longer than the head and thorax together. The elbowed antennae are attached just beyond a point one-third the distance from the tip of the snout, which extends forward and downward. The plum curculio is noticably smaller than the gouger though by actual measurements it lacks only one-sixty-fourth of an inch of being as long. Even this small numerical difference is very easily detected in such minute creatures as these. The curculio differs also in color, being dark brown variegated with spots of white, ochre-yellow and black giving a general color impression of dark brown or smoky black. Dr. Harris, the early entomologist from Massachusetts well said of the plum curculio, "looking like a dried bud when it is shaken from the trees, which resemblance is increased by its habit of drawing up its legs and bending its snout close to the lower side of its body and remaining for a time without motion, and seemingly lifeless." The thorax is uneven and the wing covers have longitudinal ridges and two black-colored humps.

In feeding on the fruit of the plum the curculio makes a characteristic crescent slit in the skin, while the gouger makes a simple circular hole. The plum gouger grub feeds entirely from the flesh of the fruit pit, while the curculio feeds from the fruit outside of, but next to, the pit. The curculio causes the fruit of the plum to drop to the ground while still very immature, though infested cherries become mature. Plum fruits containing gouger young reach maturity on the tree. It is apparent therefore that there is little reason for failing to distinguish between these two weevils or their effects upon the fruit.

OCCURRENCE IN MONTANA.

While making a hasty survey for insect pests in the Yellowstone Valley west of Billings during last summer, (1905) this weevil was found infesting the plum orchards of that region, but confined as is characteristic of the species, to native varieties. A large percentage of the fruit in infested trees had been gouged, very seriously injuring the crop. The species was first located in two orchards at Park City and later in an orchard about three miles west of Billings. We are informed by Mr. Olney Taylor, formerly of Park City, that the gouger has been in that place to his knowlledge for some eight or ten years.

Mr. Taylor affirms that another weevil, with humps on its back, believed by him to be the curculio, has been found by him in his plums at Park City. The writer has not yet seen specimens of this beetle in any stage. It is probable that any one attempting to grow plums in the Yellowstone Valley will be more or less troubled with this insect. From what has been learned of this species in other parts of the country it is apparent that it is capable of becoma very considerable factor in the production of marketable plums cn a commercial scale and our fruit growers in the central and western parts of the state as well as in the Yellowstone and tributary valleys, will do well to be on the look out for it and protect themselves.

GEOGRAPHICAL DISTRIBUTION.

As indicated by the published records, the plum gouger occurs throughout the north-central portions of the United States. It extends from Montana east to Michigan and New York and south to Texas. It is probable that in the territory here roughly indicated that this beetle has lived in a natural state for centuries before white men came to America. In fact, the beetle is believed to be native to this region.

In this connection it is interesting to note the geographical distribution of the native plum of America, *Prunus americana,* as given by Waugh in his "Plums and Plum Culture," (1901). He says "In its native forms the species *Prunus americana* ranges from Ohio to Texas and northward to Minnesota and Montana. Along the northern border of this range and eatsward in New York state it shades away insensibly into *Prunus americana nigra,* (the nigra group). Thus, in general terms, the distribution of the gouger is the same as Prunus americana. The coincidence of the distribution of the two may or may not indicate that the plum mentioned is the only food of the gouger. The insect is known to feed in the orchard from plums whose origin is other than from the American wild plum

Professor Waugh also states that, horticulturally, the American plums range from Prince Edward Island, Manitoba and Vancouver to Florida, Louisiana and Texas.

Over a large area, however, especially in Northern Iowa, Wisconsin, northern Michigan, Minnesota to the Dakotas, Montana and that part of Canada between Ontario and Vancouver, they are practically the only plums that can be grown.

It is apparent, therefore, that this very destructive insect is likely to become very much more widespread in its occurrence than at present, maturing, as it does, in a relatively short period. It will probably be able to thrive in a much more extreme climate than that of the parts of Montana it now occupies and will extend its existence into other localities.

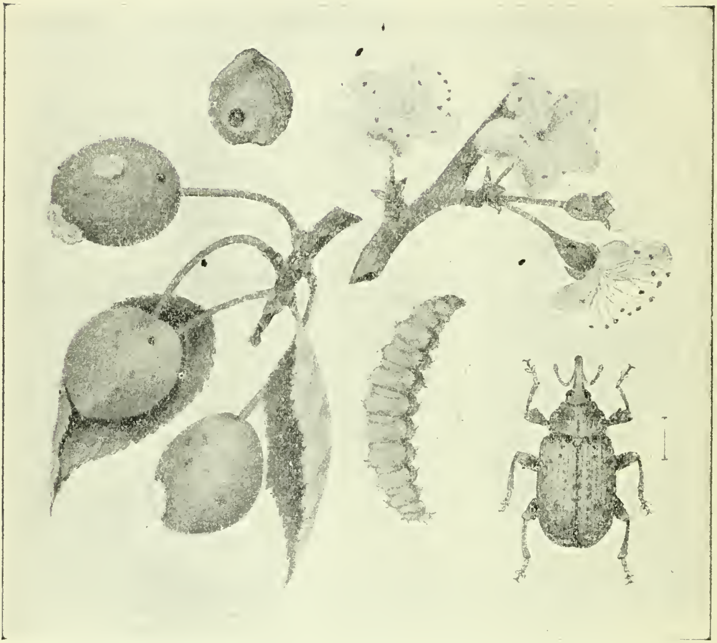


Figure 2. **The Plum Gouger.** The larva or grub and the adult are shown, together with the effects of the insect on the blossoms and fruit of the plum. (After LUGGER; cut loaned by Professor Washburn.)

EXTENT OF INJURY CAUSED BY THE PLUM GOUGER.

The plum gouger is believed to be a more objectionable pest than the plum curculio. The work of Prof. Gillette in Iowa seems to show conclusively that where the two weevils were working side by side on American plums the gouger was markedly more injurious. By actual count a much larger per cent of plums were eaten into by the gouger than by the weevil. Fruits containing grubs of the curculio soon drop to the ground, thus tending to induce a larger growth in the plums left on the tree. This process of thinning may in some cases be a positive benefit, and result in a greater market value of the crop. Even this small benefit cannot be credited to the gouger. Its ways are wholly bad, for fruits containing its larvae mature on the tree, taking their full proportion of nourishment.

Prof. Lugger, writing on this insect in his "Beetles Injurious to Our Fruit Producing Plants," after speaking of Minnesota's worst insect and fungous pests of the plum, said "The plum gouger is the most destructive of the above named insects in Minnesota. It is a reddish brown snout beetle, with a peculiar pruinose, almost velvety surface, and is of a very different shape from the better known but less common plum curculio. In the spring of 1896 the plum trees on and near the Iowa Experiment farm were in full bloom and promised rich returns, but before long one flower after another dropped off, and but comparatively few were left upon the trees and in some cases none remained. When the cause of this trouble was investigated it was found that this snout beetle was busily engaged in gouging holes in the flowers, which, in consequence, shrivelled and dropped."

The injuries from this weevil are apparent at all the stages in the development and growth of the plum. First, as the blossoms are appearing and the young plums setting, the beetles appear and destroy a large proportion of the crop at the outset, and, second, as the crop approaches maturity, a part or all of the plums are found to be rendered worthless for the market by the presence of injured spots caused by gouges made by the beetles when the plums were very young. Some of these gouged plums contain immature beetles in the pits and some none.

NATURAL HISTORY.

The life history of this important insect was first worked out by Benj. D. Walsh and published in 1866, (Vol. 5 of Practical Entomologist). Other facts have been added by more recent writers, notably, Prof. C. P. Gillette, Dr. C. V. Riley, Prof L. Bruner. The facts contained in these papers have been in a large measure verified for Montana.

TIME OF APPEARANCE.

The beetles appear early in the spring of the year, and feed on the buds and flowers, having spent the winter under some suitable shelter in the vicinity. Prof. Gillette records having taken beetles in Iowa as early as April 16th, or fully one week before the trees were in bloom. Allowing for backwardness of season, due to our altitude and elevation, for parts of Montana other than the Yellowstone Valley, Bitter Root Valley and the Flathead country, we may look for the beetle, when it becomes generally distributed, at about the tenth to fifteenth of May, and in the lower Yellowstone, Bitter Root and Flathead valleys, about two or three weeks earlier. The time of appearance of the adults is of practical importance because of the fact that at this season, and while the eggs are being deposited, is the only opportunity to effectively combat the pest, except by the laborious and inadequate method of hand-picking the infested fruits.

EGG LAYING.

After the young fruits have set and begun their growth the females deposit their eggs in them, eon egg in a plum, first boring a hole with the snout to receive the egg. The egg is placed just below the surface of the skin and is yellowish white in color, with no external markings. It is nearly spherical in shape, measuring one thirty-fifth of an inch in greatest dimension. On exposure, after being laid, the egg changes to a jet black color.

Many more wounds are made in the fruit than required for the egg. These wounds all appear throughout the growth of the plum on the tree. Many punctures are often found on a single plum. The flesh grows less perfectly near the wound, resulting in a depression surrounding each puncture. So far as the writer has observed there is no external indication to aid in determining which of the injured plums contain immature gougers.

The punctures made by this species are not easily mistaken for the characteristic slit or crescent made by the female plum curculio in depositing her eggs.

The egg laying extends over a considerable period, probably until late in July in Montana.

THE LARVA, PUPA AND ADULT.

The very small grub, upon hatching from the egg, bores directly towards the pit, which it enters, gnawing its way through the shell of the pit, which at that time is soft and easily gnawed. Some two weeks from the time of hatching are required for the larva to get inside the pit, much of this time being consumed in entering the pit. On the flesh of the pit the larva feeds until maturity, there being about enough nourishment for one larva in a single pit. By the time full size is reached the shell has become very hard, but by a wise instinct the larva is prompted to make an exit-opening, using for this purpose its powerful jaws. Then, still within the pit, the transformation to the pupa or quiescent stage occurs. From these pupa the adult beetles come and go at once to winter quarters without feeding. The hole through the hard shell of the pit is of sufficient size to admit the passage of the adult bettle which but for the hole previously made could not escape for the adult mouthparts are not adapted for such difficult tasks.

Prof. Gillette's experiments indicate to him that about twenty-six injured plums out of every hundred yielded mature insects.

REMEDIES.

It seems to be a well established fact that gouger infested plums do not fall prematurely and that, therefore, little or no good can be done by picking up and destroying fallen fruit. Prof. Gillette has recommended two remedial measures: (1) Gather and destroy all stung fruit on the trees before any of the beetles emerge. While visiting various orchards in the Yellowstone Valley on August 29th, 1905, the writer found the gougers existing as pupae in the pits of fruits. So far as seen, none had emerged on this date. August 15th or 20th would probably be a safe date to set as a limit beyond which it would be unsafe to delay gathering the stung fruit. On the other hand this work should not be done earlier than July 15th, else the larvae from late deposited eggs would escape. (2) Prof. Gillette and others have recommended the gathering and destroying of the adult beetles early in the spring. This is the easiest done, as with the plum curculio, by jarring the beetles from the trees into a suitable contrivance, described below, from which they may be taken and destroyed. By so doing, early in the season, the beetls taken will be prevented from either destroying buds and flowers or puncturing young fruit.

The essential features of a curculio catcher are an expanse of canvas or cloth, supported on a frame work. A convenient and approved form is one in which the canvas is supported on a wheel and handles, which resemble a wheel barrow. On the opposite side of the wheel from the handles is a long opening in the canvas so arranged that the wheel may be pushed close to the trunk of the tree, thereby bringing the canvas under practically the whole tree. Then the tree, if small, or the separate limbs, are suddenly jarred to dislodge the beetles, which are gathered and destroyed.

Such a catcher as is above described is designed for an orchard of a considerable number of trees. A simple sheet spread on the ground will serve for a small number of trees.

THE CORN WORM.

Heliothis armiger Hubn.

This well known insect came prominently before the people of Montana in the season of 1905 as a pest of corn. Simultaneously throughout the state, it appeared in great numbers about the middle of August, eating within the ears of both sweet and field corn. The writer made a personal examination in the corn fields of limited extent in the vicinity of Billings and found that about 90 per cent of the ears were more or less injured.

This is a species which in the cotton belt of the country is known under the name of the "Cotton Boll worm". As such it has a record of enormous destructiveness to cotton caused by the larvae eating into the bolls of cotton in a manner similar to the way they attack corn ears. Entering a bud or boll through the hole eaten through the surface, the caterpillar feeds on the internal parts killing the bud and causing it to fall.

In the southern portion of the United States it feeds also on corn but is of less prominence in this role because of the less importance of the corn crop.

GEOGRAPHICAL RANGE.

Among moths this in one of the most widely distributed species known, for it occurs in all parts of the world, being well known in Great Britian and other old world countries and having been recorded from both South and North America and the Orient, the East Indies, Patagonia, the Cape de Verde Islands, Africa and Australia. Its presence within its climatic range, anywhere on earth, need not cause surprise.

OTHER FOOD PLANTS.

Besides feeding on cotton and corn, it has been known less prominently as a destroyer of tomatoes, boring into both the fruit and the stems. It eats into pea and bean-pods and burrows into peppers, pumpkins and squashes. To some extent it feeds on various other plants, as chick-pea, leaves of hemp, leaves and buds of tobacco, leaves of alfalfa, henbane, strawberry and others. A complete list would be extensive and need not be mentioned but the ability of the species to subsist a large variety of plants indicates its destructive nature.

INJURIES TO CORN.

The injuries to corn by this species have at times been enormous. Entire fields of corn are sometimes destroyed by it. In 1860 in Kansas, during a protracted drought the corn crop was nearly destroyed. In a single county the yield of corn was cut down from 436,000 bushels the previous year, to 5000 bushels. Mr. C. V. Riley, writing in the Fourth Report of the U. S. Entomological Commission made the following statements: "During the past three seasons, 1881, 1882, and 1883 the damage to corn has been especially marked all through the South and West. It has been a common sight to meet with fields in Virginia and southward in which almost every ear was pierced, while letters from Illinois and other Western states complained bitterly of the damage done."

It seems probable that through the acclimation work with corn to be undertaken in the State the coming season we may eventually raise much more corn in some of the warmer valleys than has been believed. From time to time, we may expect this insect to appear and do more or less injury. In the fields of sweet corn in Yellowstone county last summer its injuries were so prominent that it may be accounted a pest of first importance. While some ears had only a single worm in each, many contained several.

DESCRIPTION AND HABIBTS.

The caterpillars vary greatly in color and prominence of markings. The body is almost cylindrical but tapers slightly towards the head. Prominent longitudinal stripes occur on the body the color of the stripes being darker shades of the same colors that occur between them. Some caterpillars are distinctly green in general cast, while others are distinctly dark brown but there is every graduation between these extremes. The darker specimens have on each side a narrow yellow stripe in which the spiricles, or breathing pores, occur as rather conspicuous, though small, spots of black. A few scattering short hairs arise each from a black tubercle. The full-grown caterpillar measures nearly an inch and a quarter in length.

When removed from the corn ear the caterpillar coils up after the manner of a cut worm. In fact this species belongs to the same natural family as the cut worms (Noctuidae).

The wings of the moth when expanded cover about one inch and a half. Like the caterpillar it varies greatly in color, having however, in all specimens a prevailing yellowish cast. They may be grayish or clay-yellow and many have a distinct olive green cast. The markings also vary in distinctness. Those most plainly marked have two faint brown bands across the fore wings and a more distinct one nearer the extremity of the wings and parallel with the outer edge.

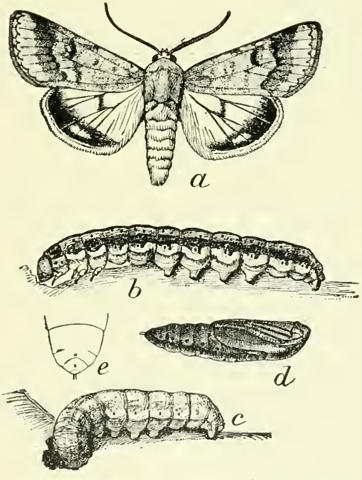


Figure 3. **The Corn Worm.** a, adult moth; b, full-grown larva; c, light colored full-grown larva; d, pupa—all natural size. (After Howard, Farmers Bulletin, 120, U. S. Department of Agriculture).

A row of black dots on a whitish back ground occurs next the edge of the wing. A crescentic discal spot occurs on each fore wing. The hind wings are much paler in color, particularly near their bases. A broad submarginal band occurs on the outer end.

The eggs, of which the moth may lay about 500, are whitish in color. It is not clear just where the eggs are laid on corn. In opening ears in the Yellowstone Valley it was noticed that while some of the larvae were nearly full grown, some were still very small. It was further observed that some large larvae were to be found in ears that appeared to be too little eaten to lead to a conclusion that the whole life of the larvae had been in the ear.

It seems probable that while the majority of the larvae as soon as hatched, begin feeding on the ears, others first feed from the leaves. It is most probable that most of the eggs were laid on or near the ears but some eggs may have been laid on the leaves.

The caterpillars enter the ears by way of the mass of parallel strands of silk at the apex of the ear. Some very small individuals were taken feeding still on the silk. From the silk they apparently pass gradually to the corn at the end of the ear, and gradually they work down, seldom, however, reaching the base of the ear except in ears occupied by several specimens. In leaving the ear the full-grown caterpillar eats a hole through the husk leaving a conspicuous dark opening.

The castings of the caterpillars together with the moisture and damaged corn within the husk, make a very unsightly mass and even slightly affected ears of sweet corn become unsalable for table use. In field corn the parts of affected ears that are not eaten by the caterpillars mature and harden up ready for harvesting, and the damage is therefore less serious in mild cases.

The full-fed larva enters the earth for pupation and there constructs a cell in the soil within which the caterpillar skin is molted off, leaving the insect in the pupa stage. In this stage the winter is passed and from the earthen cell the moth emerges the following spring. In the extreme southern part of the United States some five broods are produced, three of them feeding in corn. In Montana there are probably two broods.

REMEDIES.

In other sections of the country it has been found that this insect may be prevented from becoming very injurious to corn by hand picking the first brood which appears before the ears are formed. While hand picking is a laborious practice, counting the results which may be obtained, it seems to be advisable in fields of limited extent. Their presence may be detected by places eaten into the leaves and it is even desirable to open the ears of corn sufficiently to remove the caterpillars where they may be detected from exterior signs.

Excellent results have been obtained where the insect occurs abundantly by attracting the moths when they are just from the pupae and before they deposit their eggs, to a mixture of molosses and vinegar. The odor attracts them for a considerable distance and alighting upon the sweet mixture, become entangled and are drowned. The vinegar and molasses are mixed in a proportion of four parts of the former to one of the latter. This may be placed in a corn field in tin plates on flat ended stakes. This method has been employed in controlling the pests on cotton.

Similarly the moths have been attracted to lamps so arranged that in flying against them they fall to a reservoir below the lamp in which is placed a mixture of kerosene and water. One of the simplest forms is that in which a torch is used, the oil reservoir being soldered to the center of a broad tin dish, containing water with a small quantity of kerosine floating on top. The whole arrangement is fastened to a stake driven into the ground.

We should emphasize the importance of the destruction of the first brood in order that the second brood, which has been shown to be more injurious, may be greatly reduced in numbers.

It seems probable that flooding the garden with water about the first of September or a little later but before the ground freezes, would result in the destruction of many of the pupae in the ground. Late disking of the field after the pupae have been formed in the soil about the first of September will probably have the result of exposing many of them to the attack of insects and to destruction by severe weather.

THE WHITE LINED MORNING SPHINX.

Deilephila Lineata Fab.

From all quarters of the state this well known and beautiful moth was brought prominently to the attention of this office during the summer of 1905, and on the Experiment farm it was very abundant, the writer having found many caterpillars on various weeds on waste places. On one patch of weeds the writer stood and from one position counted nine caterpillars of various sizes, many of them nearly full grown.

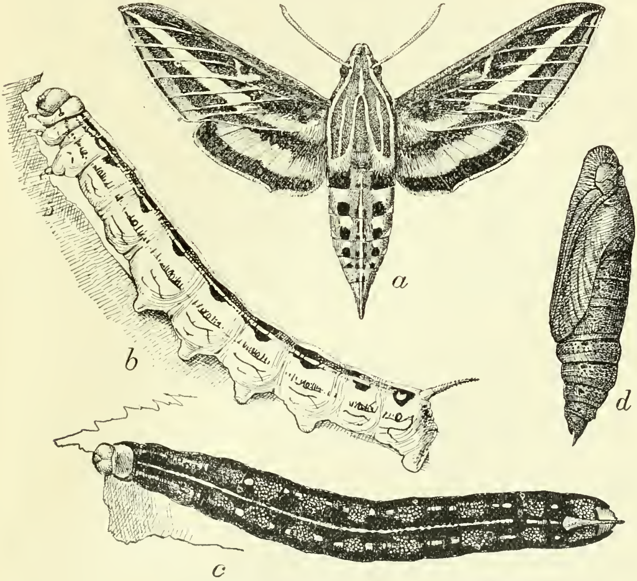
This species is given place in this bulletin not because it has been very destructive to crops, but because of the prominence with which it came before the people and because it caused some apprehension in the Yellowstone Valley as a pest of alfalfa. It has been reported in a number of instances that large numebrs of these caterpillars could be seen in alfalfa fields, and because of their large size they are believed to be a serious pest. We believe, however, that their presence in alfalfa and in other crops of value may be usually traced to the presence of some of its favorite food plants among weeds close at hand which have become exhausted, thereby leaving the caterpillars without food. It is a well known fact that this insect, while favoring a fairly restricted numebr of plants, will, when they are exhausted, feed on many others. Among these other plants it occasionally attacks a considerable number of value to man, though it seldom becomes very injurious.

GEOGRAPHICAL DISTRIBUTION.

The striped morning spinx reaches throughout the United States and is not liable to be confused with any other species, excepting, possibly, the Dark Veined Morning Spinx (*Deilephila galii*) which, in the adult stage, is rather brighter in color and lacks the diagonal lines across the fore wings and has on the top of the thorax a uniformly brownish color. The Dark Veined Morning Spinx occurs in Europe and Asia as well as the United States.

FOOD PLANTS.

The striped morning spinx is partial to purslane among the weeds, but has been taken also on bitter dock, evening primrose, elm, apple, buckwheat, watermelon, turnip, currant, gooseberry, chickweed, tomato and sugar beet. It is probable that this caterpillar will feed on almost any low-growing fairly succulent vegetation. On the Experiment Station farm we found them in greatest abundance upon the weed Oenothera aderrocaulon.



THE WHITE LINED MORNING SPHINX.

Fig. 4. **The White-lined Morning Sphinx**; a, moth; b, pale larva; d, pupa,—all natural size. (After Bureau of Entomology, U. S. Dept. Agr.)

DESCRIPTION AND LIFE HISTORY.

The beautiful moth which is the parent of the gay colored repulsive caterpillars, measures about three inches across the wings when expanded and is easily distinguished by the fore wings being of a deep olive green in back ground, with a pale buff band running lengthwise from near the base to the point of the wing, this stripe being diagonally crossed by whitish lines, which, on the outer margin of the wing, join a broad pale buff sub-marginal band. The posterior wings have a broad rosy band across them, bordered on both sides by a brownish band. The head is large, top of thorax is brownish, with longitudinal white lines, and the abdomen has, on the upper side, on each side of the middle, a row of black and white spots.

In its flight about flowers in the early morning and in the late afternoon, it very much resembles a humming bird, poises in the air before flowers after the manner of a humming bird, running its very long mouth parts into the flowers for the nectar. The writer has been charmed in observing this moth in the sunny afternoon hours in the early part of the summer, as it sought places on which to rest, the color of which harmonized with the colors on its body and wings. They may be seen to fly very rapidly over various spots in the ground, finally selecting one and settling upon it, immediately coming to rest. Approaching such a spot where a moth has been seen to alight, it is with difficulty that its position is detected.

One brood of the caterpillars only is believed to occur in Montana, the eggs for this brood being deposited in June, and the caterpillars feeding until about the middle of August. A great variation in the sie of these caterpillars has been referred to above and this variability may be attributed to the protracted period through which the eggs are laid.

Two distinct forms of larvae belong to this species, both of which are shown in the accompanying figure. Various gradations between the two may occur, but it was noticeable in our experience with the species last season that these two forms here illustrated very much outnumber the intergrades. The form shown at b has a yellowish green background, with a prominent sub-dorsal row of elliptical spots, each spot consisting of two black curved lines enclosing a bright crimson space and a pale yellow line. The spots are connected by a pale yellow stripe, edged above with black. In the other form the prevailing color is black but it has a narrow yellow line along the back, which is very conspicuous, and a series of pole yellow spots in place of the series of crimson spots of the other form.

When full-fed the caterpillars enter the earth to a depth of several inches, and by their writhing and squirming motion push away the earth into an ellipsoidal cavity. The caterpillar contracts and finally moults, the skin forming the pupa, in which state the winter is passed; the moths appearing again the next season.

This species is extensively preyed upon by a Tachnid fly, which deposits eggs upon the skin, these eggs later hatching into maggots, which bore into the caterpillar's body, eventually resulting in its death. It is very probable that the fluxuation in the numbers of moth is in large measure due to the variation in the numbers of the parasites with which they have to contend.

REMEDIES.

The caterpillar is the only stage of this insect which is in- their conspicuous markings, they may be easily detected on the plants and killed by hand. In some instanses, however, they may occur in large numebrs, making it more advisable to spray for them. They may be killed with arsenical sprays, among which Paris Green and arsenate of lead may be mentioned.

INDEX.

- Big Fork 186
- Billings 186
- Bitter Root Valley 216
- Bruner, Prof. L. 216
- Burgess, Mr A. F. 210
- Codling Moth in Montana 185
  - Arsenate of Lead 204
  - Arsenical Compounds for the Codling Moth 204
  - Banding for the Larvae 207
  - Boxes 203
  - Clean Culture 209
  - Cocoon 197
  - "Codlin" Moth 186
  - Cover Crops 209
  - Dates of Appearing of Different Stages 199
  - Egg 193
  - Egg Laying 194
  - Food for the Codling Moth 200
  - Future of the Codling Moth in Montana 191
  - Geographical Distribution in Montana 186
  - Hibernation 198
  - Horticultural Law 203
  - Larva 197
  - Means by Which the Codling Moth Spreads 189
  - Mortality Among Larvae During Hibernation 198
  - Moth 198
  - Natural History of the Codling Moth 193
  - Occurrence in Montana 186
  - Old Orchards 210
  - Paris Green 204
  - Popular Names 186
  - Potassium Cynaide 209
  - Preventive Treatment for the Codling Moth 202
  - Public Sentiment 202
  - Pupa 197
  - Remedial Treatment for the Codling Moth 202
  - Second Hand Boxes 203
  - Spraying 203
  - Spraying Machinery and Appliances 205
  - Thoroughness in Spraying 207
  - Ways in Which the Progress of the Moth May be Delayed 191
  - When to Spray 206
- Cordley, Prof. A. B. 186, 194 201
- Corn Worm 219
  - Cotton Boll Worm.... 219

  Description and Habits 220
  Geographical Range 219
  Heliothis armiger 219
  Injuries to Corn 220
  Other Food Plants.... 219
  Remedies 222
Flathead County 185, 187, 216
Fisher, Prof. R. W. 209
Forsyth 186
Frost, H. L. & Co. 206, 207
Gillette, Prof C. P. 196, 199, 216, 217, 218
Hamilton 186
Helena 186, 192
Joliet 186
Jones, Mr. B. J.... 193
Kalispell 186, 192
Lugger, Prof. 215
Marlatt, Mr. C. L. 186
Merriam, Prof. C. Hart 187, 189
Missoula 186, 187, 192, 194, 200, 204, 207
Missoula County 185
Park City 186, 212
Plum Gouger 211
  Adult 217
  Coccotorus prunicidia 211
  Egg Laying 216
  Geographical Distribution 213
  Injury Caused by the Plum Gouger 215
  Larva 217
  Natural History 216
  Prunus americana 213
  Prunus americana nigra 213
  Pupa 217
  Remedies 217
  Time of Appearing 216
Ravalli County 185
Riley, Dr. C. V. 216, 220
Slingerland, Prof. M. V. 186, 196
Simpson, Mr. 195, 200, 201
Spraymotor Co. 206
State Board of Horticulture 186
Taplor, Olney 212
Thompson Falls.... 186
Walsh, Benj. D. 216
Waugh, Prof. 213
White Lined Morning Sphinx 224
  Dark Veined Morning Sphinx 224

Deilephila lineata 224
  Food Plants 225
  Geographical Distribution 224
Woodside 186
Yellowstone Valley 212, 216, 217, 220, 222, 224

EXPLANATION OF PLATES.

PLATE I.

Figure 1.—The adult codling moth enlarged (after M. V. Slingerland, Cornell Agricultural Experiment Station).

Figure 2.—The adult codling moth natural size (after M. V. Slingerland, Cornell Agricultural Experiment Station).

Figure 3.—Side view of full grown larva of the codling moth (photograph by Professor Slingerland halftone used by Simpson in "The Codling Moth," Bulletin Bureau of Entomology, U. S. Department of Agriculture.

PLATE II.

Figure 1.—Cocoons of the codling moth showing pupae (after M. V. Slingerland, Cornell Agricultural Experiment Station).

Figure 2.—Unbroken cocoon of the codling moth showing the empty pupa case protruding just as the moth left it in emerging.

PLATE III.

The trunk of the tree in this photograph shows a bad scar caused by the breaking of a limb which affords numerous places for the larvae to hibernate in. The bands are placed on the trunk and limbs to catch them before they reach the scar. In the background the fence, door and rubbish afford the caterpillars excellent places for hiding.

PLATE IV.

Orchard owned by Senator W. J. Brennan of Flathead Co. This photograph is to be contrasted with Plate III. The ground is kept so free of weeds and all foreign matter that excellent results in fighting the codling moth might be secured. This insect has not yet reached Mr. Brennen's Orchard.